SPIXIANA	15	3	233–238	München, 1. November 1992	ISSN 0341–8391

A study of the free-living freshwater nematodes of hard substrates in the littoral of the oligotrophic Königssee (National Park Berchtesgaden, F.R.G.)

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Traunspurger, W. (1992): A study of the free-living freshwater nematodes of hard substrates in the littoral of the oligotrophic Königssee (National Park Berchtesgaden, F.R.G.). – Spixiana **15/3:** 233–238.

Samples from hard substrates in the littoral of the oligotrophic Königssee (Upper Bavaria, FRG) were examined concerning the free-living freshwater nematodes. Investigated water depths were 2, 8, and 20 metres. The largest abundance and biomass of nematodes were found at a water depth of 2 m. A total of 29 species (non Dorylaimidae) and an unknown number of Dorylaimidae species were found. *Rhabdolaimus terrestris* and *Chromadorina bioculata* were the most abundant species at 2 m depth, *Chromadorina bioculata* and representatives of the genera *Eumonhystera* and *Plectus* preferably occured at 8 m depth and *Chromadorina bioculata, Tripyla glomerans* and representatives of the genus *Plectus* at 20 m depth. Deposit-feeders and epistrate-feeders were predominant at all three water depths. There was a remarkable increase of predators/omnivores at 20 m depth.

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Introduction

The nematode fauna of West German lakes has scarcely been studied. After the studies by Micoletzky (1922) on the Lake of Constance and lakes of Northern Germany and by Schneider (1922, 1925) on lakes of Eastern Holstein the present investigation on the nematofauna in the littoral of the Königssee is the first study of this type in Germany for 60 years. It further for the first time investigates fauna and ecology of nematodes from a hard substrate of a Bavarian lake.

In addition to a number of species, the relative abundance of the nematodes and the distribution of feeding types were examined. The study further improves our understanding of the limnology of Königssee, which had extensively been studied by Siebeck (1982).

Study area

The Königssee is located in southeastern Bavaria in the National Park Berchtesgaden. It is the last large oligotrophic lake in West Germany, which, due to its almost intact surroundings, has sufficiently constant characteristics to make it ideal for an analysis of its ecosystem. In the following, some important morphometric and hydrographic data of the Königssee are listed (Siebeck 1982):

Geographic location:	12°58′E, 47°33′N
Altitude:	603.3 m above sea level

Surface area:	5.2 km^2
Volume:	511.8 × 10^6 m^3
Maximum depth:	190 m
Mean depth:	98.1 m

The study area of the investigation was limited to the hard substrates of two sampling sites (wall of rock and scree) at the western shore north of St. Bartholomä. Five samples were taken both in spring (26.4.1984) and in autumn (2.10.1984) with a suction apparatus (area: 1600 cm^2) at water depths of 2 m, 8 m and 20 m.

Methods

The benthos samples were extracted with a modified suction apparatus (Blank et al, 1985). Divers suctioned the soil surface within a plastic frame (area: 1600 cm^2) with a suction tube. The soil was filtered through a net with a mesh size of 100 μm. The samples were fixed in 4% formalin, and the nematodes were sorted using a 40 × magnification binocular. Taxa were determined under a microscope (magnification: 1250 ×). The nematodes were mounted in glycerol (Seinhorst, 1959, 1962).

Results and discussion

Estimation of the total abundance and biomass

The abundance of nematodes decreased between 2 m and 20 m depth (Table 1). At 2 m depth the mean density was between 110 ind/100 cm^2 and 653 ind/100 cm^2, at 8 m depth between 13 ind/100 cm^2 and 116 ind/100 cm^2, and at 20 m depth 2 ind/100 cm^2 − 12 ind/100 cm^2. The frequency was significantly (U-test after Mann-Whitney) higher in spring as compared to autumn in 8 m ($Z = 1.984$; $p < 0.05$) and 20 m ($Z = 2.319$; $p < 0.05$) on the wall of rock and in 2 m ($Z = 2.611$; $p < 0.01$) on the scree, while in 8 m ($Z = 2.619$; $p < 0.01$) on the scree the difference was significantly lower. No statistical difference was observed in 2 m on the wall of rock respectively in 20 m on the scree. The density of nematodes is less on hard substrates than on soft sediment. Comparative samples from soft substrates of Königssee close to St. Bartholomä showed an abundance of up to 3560 ind/100 cm^2 at 2 m depth, 284 ind/100 cm^2 at 8 m depth and 228 ind/100 cm^2 at 20 m depth. In her study of the eutrophic Mikolajskie-Lake (Poland) Prejs (1970) found up to 3800 ind/100 cm^2 in the littoral (0.4 m depth) while the study of the oligotrophic lake Pääjarvi (Finland) by Holopainen and Paasivirta (1977) revealed a maximum density at 2 m depth (1860 ind/100 cm^2). The mesh size of the used nets was 45 μm resp. 100 μm.

Table 1. Estimation of the abundance (A) and the biomass (B) of the nematodes in the examined sampling sites, wall of rock and scree, in spring (26.4. 1984) and autumn (2.10.1984). Each value indicates the mean ± standard error of 5 samples.

		Spring		Autumn	
sampling site	depht (m)	A (Ind/100 cm^2)	B (μg/100 cm^2)	A (Ind/100 cm^2)	B (μg/100 cm^2)
wall of rock	2	653±213	119±33	586±187	46±13
	8	116±43	33±17	57±13	31±16
	20	12±5	8±6	2±4	0.6±0.3
scree	2	395±85	88±25	110±22	26±5
	8	13±4	3±2	77±34	49±13
	20	5±4	3±2	12±5	52±8

The biomass of the nematodes was calculated as the fresh weight according to Andrássy (1956). In the examined depths a decrease of the biomass of nematodes was observed following abundances. The large biomass of nematodes in the sampling site scree in autumn (mainly at 20 m depth) can be explained by a relatively high number of large sized nematode species (i. e. *Tripyla glomerans*).

Species and relative abundance

In total, twenty nine species (excluding Dorylaimidae) were found. The family Dorylaimidae was represented by several species of which only *Laimydorus flavomaculatus* and two species of *Mesodorylaimus* could be recognized. The species number of the family Dorylaimidae may be about five. Table 2 gives the relative abundance of the species of spring and autumn samples at the different depths. The taxonomic classification of the orders Chromadorida, Monhysterida, Enoplida and Rhabditida is done following Lorenzen (1981), the order Tylenchida according to Maggenti et al. (1987) and the order Dorylaimida as in Coomans and Loof (1970).

Table 2: Species list of free-living freshwater nematodes in the littoral of Königssee with their relative abundance (%) in spring (sp) and autumn (au) and their feeding type (FT = feeding type; D = deposit feeder, E = epistrate feeder, S = nematodes with buccal sting, P = predator/omnivore).

	Depth						
	2 m		8 m		20 m		FT
	sp	au	sp	au	sp	au	
Class SECERNENTEA							
Order Tylenchida Thorne, 1942							
Fam. Tylenchidae Örley, 1880							
Tylenchus spec.	–	–	–	–	1.5	3.8	S
Filenchus spec.	–	–	<1%	–	–	–	S
Fam. Criconematidae Taylor, 1936							
Hemicycliophora spec.	–	<1%	–	–	–	–	S
Fam. Aphelenchoididae Skarbilovich, 1947							
Aphelenchoides spec.	2.9	1.7	–	<1%	–	–	S
Order Rhabditida Chitwood, 1933	–	–	–	–	–	–	
Class ADENOPHOREA							
Order Chromadorida Filipjev, 1929							
Fam. Chromadoridae Filipjev, 1917							
Chromadorina bioculata (Schultze in C., 1857)	27.6	14.9	12.4	22.5	64.2	11.5	E
Fam. Ethmolaimidae Filipjev and Stekh., 1941							
*Ethmolaimus pratensis*De Man, 1880	<1%	–	–	9.3	–	–	E
Fam. Leptolaimidae Örley, 1880							
Aphanolaimus aquaticus Daday, 1894	<1%	<1%	–	<1%	2.4	–	D
Fam. Chronogasteridae Gagarin, 1975							
Chronogaster spec.	–	<1%	–	–	–	–	D
Fam. Plectidae Örley, 1880							
Anaplectus granulosus (Bastian, 1865)	–	<1%	1.5	1%	–	–	D

	Depth 2 m sp	2 m au	8 m sp	8 m au	20 m sp	20 m au	FT
Plectus aquatilis Andrássy, 1985							
Plectus cirratus Bastian, 1865	12.8	4.1	21.9	46.5	14.2	11.5	D
Plectus aff. *parvus* Bastian, 1865							
Plectus tenius De Man, 1880							
Fam. Teratocephalidae Andrássy, 1958							
Euteratocephalus crassidens (De Man, 1880)	–	<1%	–	–	–	–	D
Fam. Prismatolaimidae Micoletzky, 1922							
Prismatolaimus cf dolichurus De Man, 1880	–	<1%	–	–	–	–	E
Fam. Rhabdolaimidae Chitwood, 1951							
Rhabdolaimus terrestris De Man, 1880	50.8	71.6	12.4	5.0	2.4	–	D
Order Monhysterida Filipjev, 1929							
Fam. Monhysteridae De Man, 1876							
Monhystera paludicola De Man, 1881	–	–	2.2	–	–	–	D
Eumonhystera filiformis (Bastian, 1865)							
Eumonhystera pseudobulbosa (Daday, 1896)							
Eumonhystera similis (Bütschli, 1873)							
Eumonhystera simplex (De Man, 1880)	1.1	<1%	38.0	10.8	4.8	15.4	D
Eumonhystera spec.							
Eumonhystera vulgaris (De Man, 1880)							
Order Enoplida Filipjev, 1929							
Fam. Ironidae De Man, 1876							
Ironus tenuicaudatus De Man, 1876	<1%	<1%	–	–	2.4	–	P
Fam. Tobrilidae De Coninck, 1965							
Tobrilus gracilis (Bastian, 1865)	–	–	2.2	<1%	2.4	–	P
Fam. Tripylidae De Man, 1876							
Tripyla glomerans Bastian, 1865	<1%	<1%	<1%	<1%	2.4	38.5	P
Fam. Mononchidae Filipjev, 1934							
Mononchus aff. *truncatus* Bastian, 1865	–	–	<1%	–	–	–	P
Order Dorylaimida Pearse, 1942							
Fam. Dorylaimidae De Man, 1876	3.6	4.3	2.9	2.3	–	–	S
Fam. Qudsianematidae Jairajpuri, 1965							
Epidorylaimus spec.	–	–	4.4	1.2	2.4	19.2	S
Fam. Actinolaimidae Thorne, 1939							
Paractinolaimus macrolaimus (De Man 1880)	<1%	<1%	–	–	–	–	S

At 2 m depth 21 species, at 8 m depth 22 species and at 20 m depth only 12 species were determined (Dorylaimidae not included). The Dorylaimidae were present only at 2 m and 8 m depth.

There is a high relative abundance (>10 %) of individuals of *Rhabdolaimus terrestris* and *Chromadorina bioculata* at 2 m depth. With increasing depth, there is a distinct shift in dominance. At 8 m depth, the genus *Plectus* (mainly *P. aquatilis*) dominates, followed by the genus *Eumonhystera* (mainly *E. filiformis)* and *Chromadorina bioculata.* At 20 m depth, *C. bioculata* is the dominating species followed by *Tripyla glomerans* and the genus *Plectus* (mainly *P. aquatilis). C. bioculata* is the only species with a high relative abundance (>10 %) at all depths. Meschkat (1934) observed that this species secretes long threads of sticky substance from its caudal glands. This facilitates a quick attachment to the substrate and might also play a decisive role in the colonization of hard substrates.

Rhabdolaimus terrestris seems to be an abundant species in the region of the Alps, in terrestrial as well as in aquatic biotopes. In his studies on freshwater nematodes of the Eastern Alps Micoletzky (1914) found this species mainly on rocks with periphyton. According to the study of Pehofer (1977) in the Piburger See, *R. terrestris* is the most abundant species up to a depth of 6 m. Gerber (1981) found a high abundance of this species in the grassy heathlands and in the cushion plants level in her studies on the nematode fauna of alpine soils in the area of Mount Großglockner.

Classification of feeding types

Nutrition and food availability is a factor of great significance for species composition, abundance and distribution of aquatic nematodes. Our knowledge of feeding methods unfortunately is still incomplete, and the diets are often very varied (Yeates, 1979). For this reason the morphology of the buccal cavity, a common factor for classification (Wieser 1953; Banage 1963, 1964; Jensen 1987), has to be used as a first approximation to classify the nematodes according to their feeding types.

Figure 1 gives the distribution of the feeding types. At 2 m and 8 m depth, deposit feeders (without tooth in buccal cavity) and epistrate feeders (with tooth in the buccal cavity) represent 90% of the nematofauna, with the deposit feeders being the dominant group (65–70%). The two groups comprise different feeding types but explore the same food resources of algae and bacteria.

This is in good agreement with the study of Siebeck (1982), who found the maximum of phytoplankton at 5–10 m depth. The most abundant algae were Bacillariophyceae and Chrysophyceae. Deposit feeders swallow the whole food item (particulate feeders) while epistrate feeders are able to break open cell membranes of food items in the buccal cavity (Jensen, 1987). This may be an advantage in the competition for nutrition because the portion of not readily degradable organic substance increases with increasing depth according to Siebeck (1982). At 20 m depth, both groups form 70% of the nematode population but with a dominance of the epistrate feeders: 45% against 25% of deposit feeders.

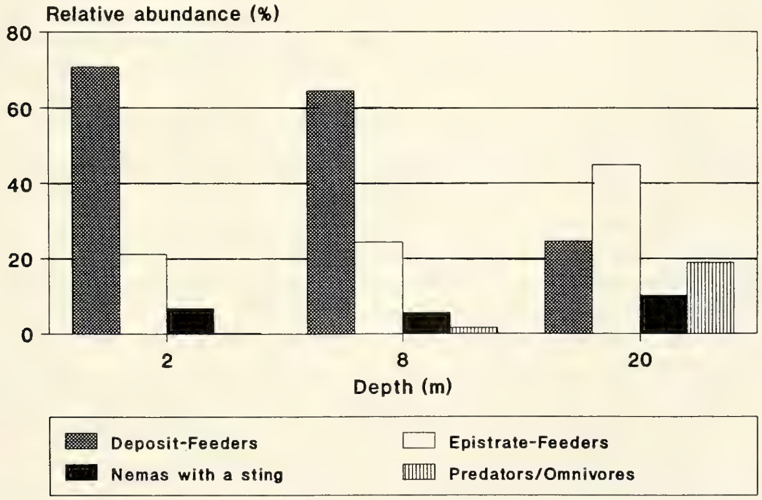

Fig. 1. Relative abundance of various feeding types at the three examined water depths of Königssee.

The transition from the trophogene to the tropholytic zone (at about 15 m depth according to Siebeck, 1982) obviously has a significant influence on the composition of the nematode fauna: There is a noticeable increase of the predators/omnivores from 1% at a depth of 2 m and 8 m to almost 20% at 20 m.

Acknowledgement

I am grateful to Mrs. Astrid Drews-Schmidl and Mr. Carlos Drews (Cambridge, U. K.), for correcting the wording and for valuable comments on the manuscript.

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